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ESTIMATING THE AREA IN LOGGING ROADS BY DOT SAMPLING ON AERIAL PHOTOS

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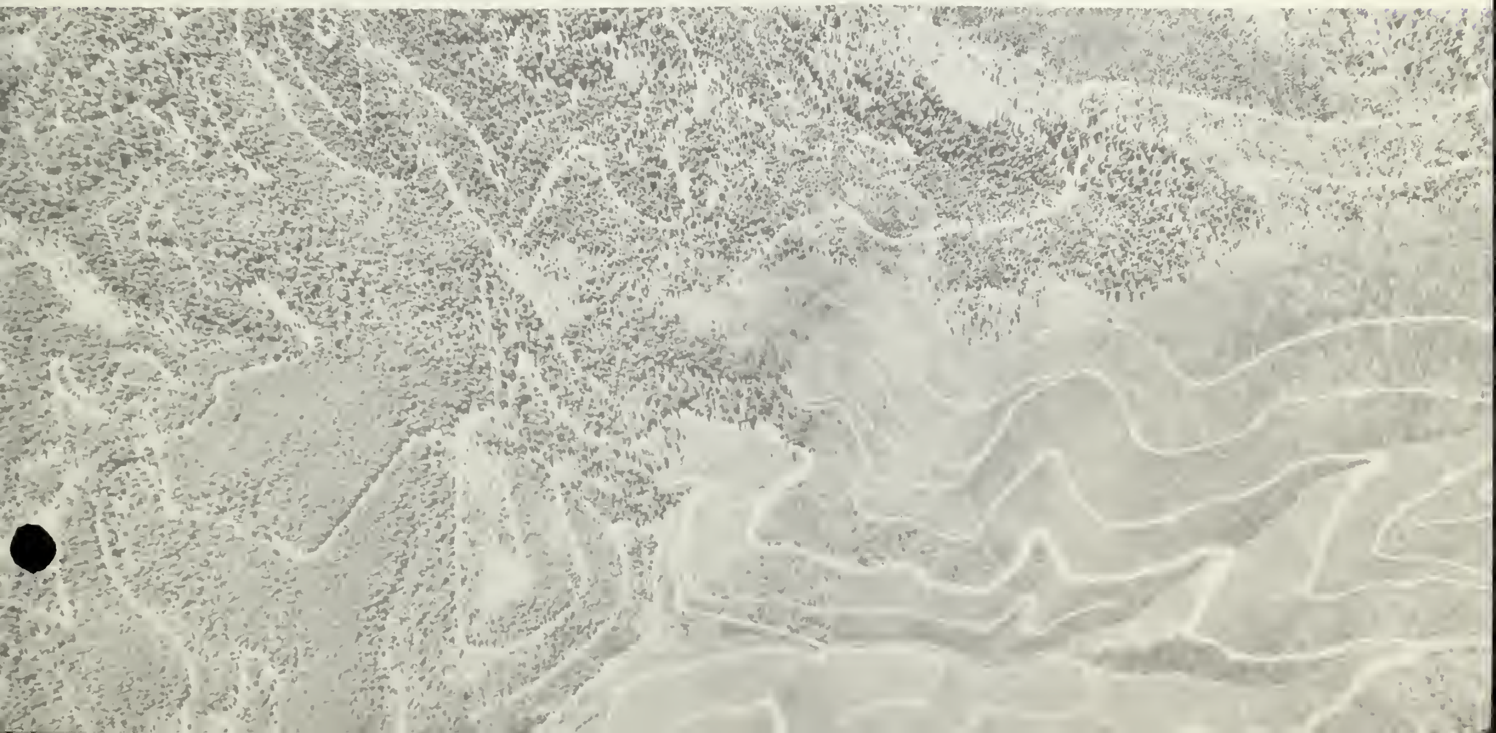
Dot sampling on aerial photos can provide a cheap but efficient estimate of the areas bared by haul roads, jammer roads, skid trails, and landings constructed during the timber harvest.

The extent of such disturbance is important to the forest manager since much of this area may be removed from future production. And since these logged-over areas may become a source of damaging runoff and sediment, watershed and wildlife managers have an even more immediate interest. Detailed studies of the amount and type of disturbance have been carried out on several experimental forests, but application of these findings or even a delineation of the entire problem probably would require more extensive investigations.

In most studies the area bared during logging has been computed from ground measurements consisting of the length and average width of truck haul roads, jammer roads, tractor skid trails, landings, and other measurable disturbance. This procedure may be justified on experimental studies, but it is likely to prove too expensive to be practical on large timber holdings or watersheds.

The investigative study reported here illustrates the possibility of measuring these disturbed areas by dot sampling on aerial photos. Specifically, we wanted to know the following:

1. If the area in roads, skid trails, and landings visible on aerial photos of recent logging could be effectively measured by dot sampling.



Road pattern of jammer logging, Coeur d'Alene National Forest

2. How the area so computed would compare with the areas measured on the ground and used as basic data in recent management studies.

3. The comparative costs of the two methods of measurement.

THE STUDY

The initial dot counts were made on 1:16,000-scale photos of the St. Joe National Forest in northern Idaho. Six recently logged sample areas varying from 100 to 160 acres were outlined on the aerial photos (fig. 1). Four of these samples were examples of jammer skidding on slopes varying from 10 to 65 percent; the other two were of tractor skidding on slopes varying from 5 to 50 percent. Timber types included western white pine and spruce-fir.

A dot grid having 256 dots per square inch was oriented over each sample area. The photos were then viewed stereoscopically, and each dot within a 2- x 2-inch square was tallied as either in or out of the bared area. In jammer logging, bared areas included haul roads, jammer roads, turn arounds, and spoil areas. In tractor logging, bared areas were tallied as haul roads and landings or as tractor skid trails. Wherever dots fell in roads, back slopes, fills, or spoil areas, they were tallied as part of the bared area. Disturbed areas were identified on the aerial photos both by shape and by tone, which reduced the possibility of including eroded areas not due to logging. When dots fell on tree crowns obviously overhanging roads, they were tallied as part of the roads. This intensive sampling method made it possible to measure bared area in cuts, fills, turns, and road junctions not always accounted for in ground surveys.

For statistical evaluation, dots were tallied separately by subsamples consisting of 1/2- by 2-inch strips across each sample area. Four such strips of approximately 40 acres each were included in a 160-acre sample block. From these dot tallies we computed the proportion of bared land in each sample shown in the following summary:

Jammer Logging

Total dots classified: 3,712
Dots in bared area: 772, or 20.80 percent.

Percents within the four samples ranged from 20.41 to 21.09, and within the 16 subsamples from 13.67 to 25.39.

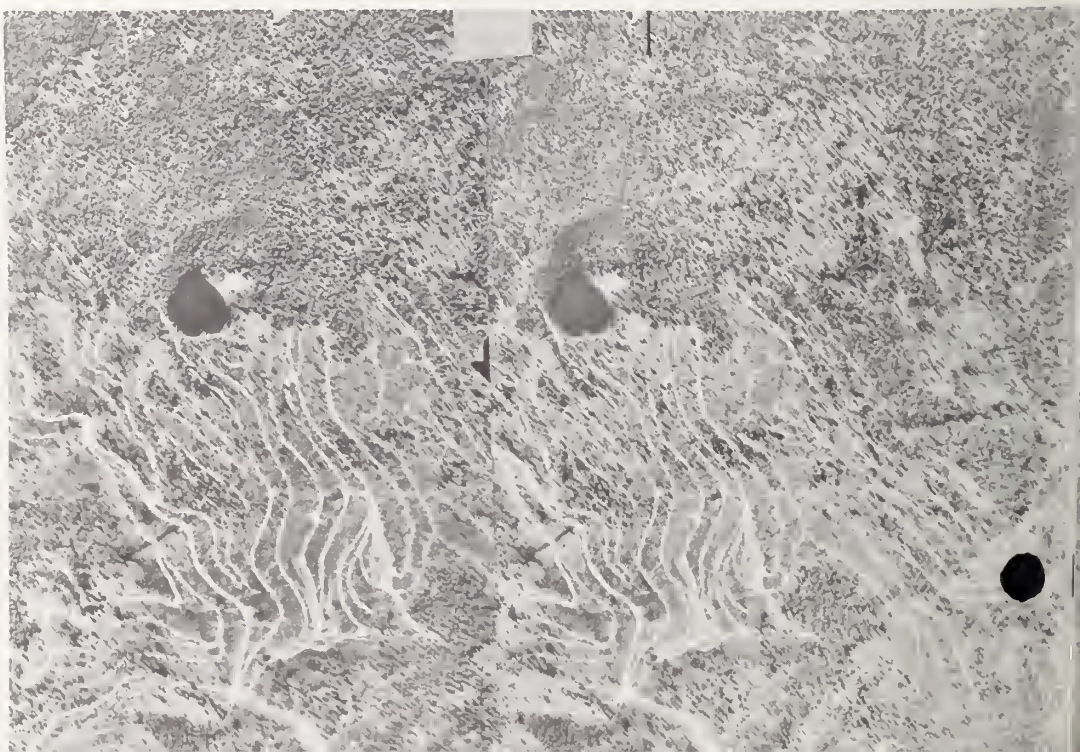


Figure 1.--This stereogram illustrates the network of jammer roads on a typical operation where the area in roads is 21 percent of the 160-acre sample.

Tractor Logging

Total dots counted: 1,792
Dots in truck haul roads and landings: 121, or 6.75 percent
Dots in tractor skid trails: 321, or 17.92 percent.

The total bared area was thus 24.67 percent, and this varied from 23.31 to 25.68 on the two samples and ranged from 18.75 to 33.20 percent on the seven subsamples examined.

Fiducial probabilities indicate a sampling error less than ±1.47 percent in the jammer estimate and ±1.97 percent for the tractor estimate 19 times in 20.

The literature contains few references that could offer direct comparisons with the data obtained by dot sampling technique. However, the report of a recent study[1] made on the Boise Basin Experimental Forest includes estimates of area occupied by haul roads and tractor skid trails by cutting compartment. This report states, "Truck haul roads were chained, assigned an average width of 25 feet and plotted on large scale topographic maps. Landings were paced, referenced to haul roads, and also plotted."

For comparison we obtained prints of the postcutting 1:13,000-scale aerial photos from the Boise Basin Experimental Forest. On these we outlined four cutting compartments for which detailed records were available (fig. 2). Truck haul roads and landings are obvious on these photos.

The 256-dot-per-square-inch sampling grid was oriented over each compartment in turn, and all dots within the compartment were examined under stereo and classified as either in or out of haul roads and landings. Percentages of area in haul roads obtained by dot sampling were then compared to those obtained by ground measurement (table 1).

Table 1.--Area in haul roads estimated from photo dot sampling compared to area estimated from ground measurements

Compartment		Proportion in truck roads and landings			
Number	Area logged	From photo dot sample		From ground measurement	
	Acres	Acres	Percent	Acres	Percent
11A	39.02	1.73	4.44	1.08	2.77
11B	45.45	4.11	9.04	2.69	5.92
15 and 16	79.46	4.33	5.45	3.97	5.00
Total	163.93	10.17	6.20	7.74	4.72

Since the computed areas differ, we made an additional comparison of the dot sampling versus the measurement method by using a compartment for which 1:4,680-scale photos were available. Instead of using ground estimates of road width, we laid off 100-foot stations on these photos and scaled the width at each of the 20 cross sections. Width of these cross sections ranged from 15 to 44 feet, with an average of 28.8 ±1.7 feet. Using this mean and a scaled road length of 2,300 feet, we computed the area in haul roads. We then dot-counted the entire 54.77A compartment under stereo, using a 256-dot grid and classifying each of the 4,245 dot samples as either in or out of the haul roads and landings. The areas in truck roads and landings computed by these two methods and by the ground method were:

	Photo dot sample	Photo measurement	Ground measurement
Acres	1.65	1.52	1.47
Percent	3.02	2.78	2.68

[1] Haupt, Harold F. Variation in [redacted] areal disturbance produced by harvesting methods in ponderosa pine. Jour. Forestry (in press).

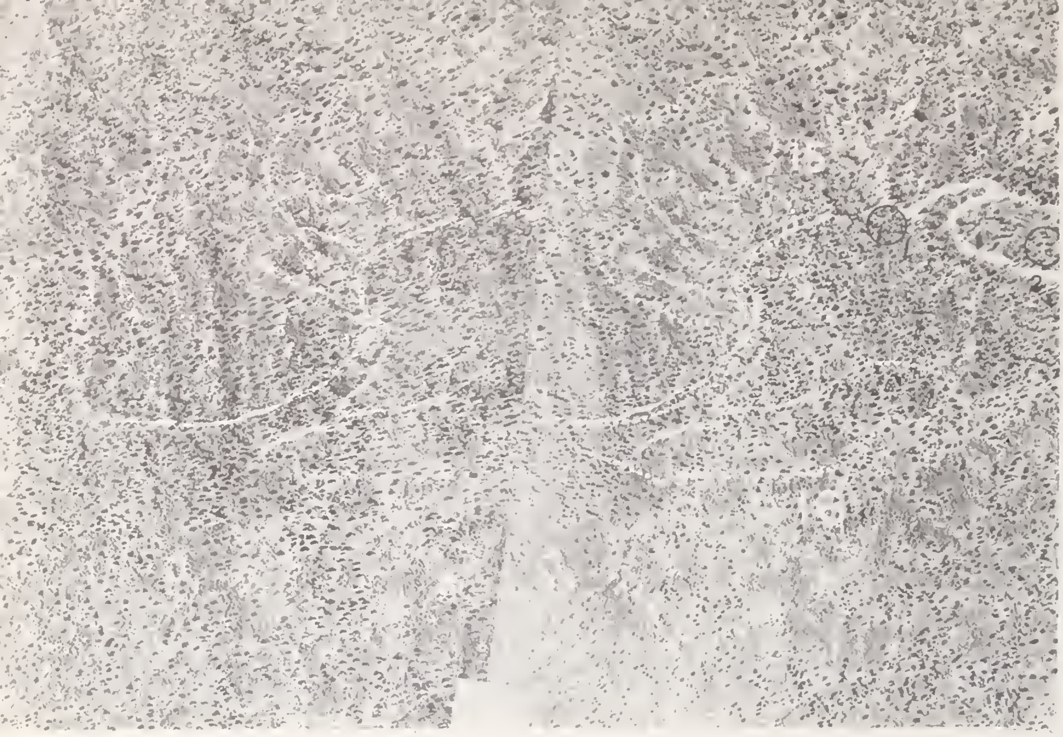


Figure 2.--Boise Basin Experimental Forest cutting compartments 15 and 16 with proportion of the area in roads estimated as 5.45 percent from photo dot count and 5.00 percent from ground measurement.

DISCUSSION

For the compartments checked (table 1), the photo dot sampling technique results in an area that appears to be significantly larger than that obtained by measuring cross sections on the ground. The difference is more apparent than real, however, since the sampling error of the ground measurement can only be roughly estimated. When photo dot sampling is compared with a photo measurement technique patterned after the method used on the ground, we find the two proportions are not significantly different, although even here the measurement technique results in slightly less area than that obtained by dot counting. Ground or photo measurement of the length of road is simple and may be very precise, but accurate estimates of road width even by means of a series of measured cross sections are subject to considerable sampling error.

In steep country where variations in road width are accentuated by differences in slope, the measurement on the ground of a sufficient number of cross sections may be difficult and time-consuming. Measuring on photos, in a logging compartment where roads constituted only 3 percent of the gross area, required 1½ times as long as the photo dot sampling.

It can be shown that dot sampling does measure variations in road width due to back slopes, fills, turns, and road junctions that are almost impossible to measure by ground techniques, and that the cost has little relation to the topography and intensity of the road system. Dot classification for the entire 5,500 dots originally classified required 4.85 man-hours--an average rate of 1,134 per man-hour. At this average rate the 2,079 dots classified on the 190 acres of Boise Basin Forest would require 1.8 man-hours. Computations would increase this to 2 man-hours.

A conservative estimate of the time required to measure the length of the roads on the ground and compute areas by average width obtained from a reasonable number of measured cross sections is 2 or 3 man-days for these same 190 acres. This direct comparison indicates that dot counting on aerial photos can be used to measure the area in logging roads for about 10 percent of the present cost of obtaining ground measurements.

The photo technique described in this paper has been confined to that necessary to obtain a good estimate of the area bared by haul road construction and other logging disturbance. The extent to which this bared area may affect watershed, wildlife, and timber management is a subject for much more intensive and conclusive studies properly made on the ground. But an integrated method whereby basic areas are determined by dot sampling on photos, and are subsampled on the ground by using a portion of the same pinpoint locations, should be valuable to researchers and timber managers interested in knowing how greatly logging operations disturb the ground surface of these watersheds.